The scale of segregation: ancestral groups in Sydney, 2011

Most studies of urban residential segregation analyse it at a single-scale only, usually the smallest for which relevant census data are available. Following a recent argument that such segregation is multi-scalar, this paper reports on multi-level modelling of the segregation of 42 ancestral groups in Sydney, Australia, looking at its intensity at four separate scales in which segregation at each scale is presented nett of its intensity at all higher-level scales. Most groups are more segregated at the macro- and micro-scales than at two intermediate meso-scales, with variations across them reflecting their size, recency of arrival in Australia, and cultural differences from the host society. The findings are used as the basis for developing a multi-scale appreciation of residential patterning.

Keywords: segregation, multi-level modelling, ancestry groups, Sydney

Most studies of urban residential segregation analyse it at a single scale only, usually the smallest for which relevant census data are available, using these as surrogates for urban neighbourhoods. Fowler (2015, 1) has argued that segregation occurs 'at scales both smaller than and larger than the neighborhood itself', however, remarking that '[u]ntil recently our capacity to represent these multiscalar processes with quantitative measures has been limited'. This constraint has been removed in work by Reardon et al. (2008, 2009; see also Lee et al., 2008, and the parallel work by Östh et al., 2014a, 2014b) which used agglomeration algorithms to calculate segregation indices at a range of spatial scales, allowing insights to the levels of segregation at those various scales and how they vary across an urban system (see also Krupka, 2007).

Calculating and comparing segregation indices at various spatial scales, although an interesting and potentially important advance on the single-scale concentration of most studies, could well produce potentially misleading findings. Tranmer and Steel (2001) showed, both theoretically and empirically, that if geographical variability, as in the distribution of an ethnic group across a city's residential fabric, is multi-scalar then if one of those scales is omitted from the analysis, measures of segregation at a smaller scale than that omitted can be exaggerated; any measure of segregation at a micro-scale must incorporate, to an unknown extent, the level of segregation at the larger scale. Resolution of this problem calls for a procedure that decomposes any measure of segregation into its scale components – as recognised initially by Duncan et al. (1961)[1] and later essayed by Voas and Williamson (2001; see also Reardon et al., 2000; Fischer et al., 2004; Johnston et al., 2003; Parisi et al., 2011) – while recognising that with most administrative data sets both the number of scales and the boundaries of units at each scale are somewhat arbitrary.

In one of the few attempts addressing urban residential segregation's multi-scalar nature, Fischer et al. (2004, 37) sought to distinguish 'whether groups live apart because members cluster into different neighborhoods, communities, metropolitan areas or regions', using a 'traditional' measure (the entropy index: Parisi et al., 2011, also used it in a comparable evaluation of segregation levels at multiple scales). However, this took no account of the internal spatial structuring of the units at each

[1] Indeed, Duncan et al. (1961, 84) recognised the issue later formalised by Tranter and Steel: 'if one system of areal units is derived by subdivision of the units of another system, the index computed for the former can be no smaller than the index for the latter, and usually will be larger. Thus the index of concentration on a county basis will exceed the index on a State basis, because the county index takes into account interstate concentration'.

scale and the decomposition approach did not fully respond to Tranmer and Steel's important argument. A recently-developed modelling procedure does (Jones et al., 2015); it is applied here to the geography of population groups within the Sydney metropolitan area defined by their ancestry. (A recent study of spatial assimilation in Sydney and Melbourne – Edgar, 2015 – uses only a single, relatively coarse, spatial scale.) We first illustrate cartographically the veracity of Fowler's argument regarding the multi-scalar nature of residential segregation there, and then report results of the modelling – rigorous statement of the extent to which each of the groups analysed is segregated at each scale, nett of any segregation at higher scale levels. Fowler (2015) and Lee et al. (2008, 785) also argued that their findings indicated 'an even greater need for scale-specific theorizing' – though neither undertook this task – and in a final section we essay a preface to such a theorization.

Sydney's diversity

Sydney is one of the world cities whose ethnic diversity increased very significantly over the last 50-60 years. Until the end of the Second World War its population was dominated by people with roots in the British Isles (both the United Kingdom and Ireland). Subsequent waves of immigrants came from many parts of Europe in the 1950s and 1960s, and then – after the end of the 'White Australia' restrictive immigration policy in the early 1970s – from parts of southeastern, eastern and southern Asia and, increasingly, other parts of the world, including substantial refugee streams (Forrest et al., 2006, pp. 443-445). The resulting multicultural city has a wide range of ethnicities (Forrest & Johnston, 2001; Johnston et al., 2001) and to map and model it we use 2011 Australian census data to categorise Sydney's population according to their ancestry; the Australian census does not, unlike several others, ask respondents their ethnic identity. The Australian Bureau of Statistics' (ABS) Tablebuilder facility allows access to 100 per cent of the census data, and was used to develop cross-tabulations for a hierarchy of sub-areas: collectors' districts (CDs, now called SA1s); suburbs (SSCs), built from SA1s that, singly or in combination, form an approximation of Gazetted Localities; functional regions (SA2s), conforming to whole suburbs and combinations of whole suburbs or parts thereof and representing community areas seen as interacting together socially and economically); and regional areas (SA3s) – aggregations of SA2s representing sub-labour markets within major metropolitan labour markets (Australian Bureau of Statistics, 2011). This selection at various scales is somewhat arbitrary. Nevertheless, in line with the later discussion of residential location-decision-making, choice of these scales allows exploration of the relative importance of clustering in small neighbourhoods (the finest, or micro-scale), in suburban districts (the meso-scales), and in broad segments of the metropolitan areas (the macro-scale divisions to some of which groups may be attracted and others avoid).

The census asked respondents to nominate one or two ancestries; no instructions were given as to the ordering of the two choices and ABS made none. Rather each ancestry choice was recorded as of equal value, so the multi-choice option provided in Tablebuilder was used here. Each group's ancestry is, in most cases, associated with a particular country; those otherwise too small to be included in our analyses separately were allocated to the nation states from which the (mostly overwhelming) majority derived – for example Assyrians to Iraq, Hmong to Laos, Sikhs and Indian Tamils to India. A few sub-groups from a country (such as the Sri Lankan Tamils who are separately identified from other Sri Lankans, or Maori from New Zealanders) or those with a different identity (notably those who give their ancestry as Jewish) were separately identified here. The result was the production of data on 42 separate ancestry groups from multiple generations and of sufficient size (more than 2,000 members; the groups are all listed in the subsequent tables) to submit to our adopted analytical procedure using the four spatial scales previously identified. The smallest are the 9,098 SA1s for which data are available, with an average population size of 447. These are nested into 555 suburbs (average population, 7,319), which in turn are nested into 217 districts (SA2s: average population, 18,720) – in practice, SA2s are existing suburbs or (mostly) combination of

suburbs; finally, the SA2s are nested into 45 SA3 regions of Sydney whose average population is 99,079. These are referred to in the text as Sydney's micro-, meso1-, meso2- and macro-scale divisions. Based on first responses to the ancestry question, these 42 groups comprised 3,461,638 individuals enumerated in the 2011 census, some 93 per cent of Sydney's total population then; the remaining 7 per cent – members of small ancestry groups – are omitted from this study.

These 42 separate ancestry groups involve a much finer-grained analysis of ethnic residential patterns than common in most studies, and takes up Boyd's (2002, 1055) plea for studies of specific ethnic groups. Those of US cities generally focus on just four, for example (three of which – Asians, Hispanics and Whites – are internally heterogeneous) whereas those using UK data focus on less than twenty. Selection of as many as 42 reflects the richness of the Australian population heterogeneity as captured in the census data and the multi-cultural, multi-ethnic, multi-national nature of a city region. More importantly, the fine-grained approach relates more exactly to the migration and residential-location-decision processes involved in creating Sydney's complex residential fabric. Many migrants – especially those in the early years of movement from one country to another – move through chain migration processes. Individuals, families and households who move to a city encourage their friends and kin to join them. Having established homes in particular areas, where close proximity to their co-ethnics aids community socio-cultural cohesion while facilitating economic integration into the wider society, later arrivals tend to join them in the same area, and in this way segregation patterns emerge and are re-structured.

Rather than analyse residential patterns of broad racial groups such as Asians, therefore, exploring the geography of several ancestral groups who together might be classified as Asians focuses on groups that are likely to cluster together and apart from others (while acknowledging that many of these ancestral groups are heterogeneous too: Indians, for example, differ in their language, religion and region of origin – all of which may influence who they choose to congregate within Sydney). The emphasis, therefore, is on ancestral groups who – in the first generation of migrants especially, and many of those living in Sydney are first-generation immigrants plus their children – are likely to congregate spatially, and by doing so distance themselves from other groups. For some groups, such distancing may not be part of their residential location-decision-making processes; North Americans are unlikely to shun areas where those with UK ancestry are resident, for example, but including them in the list of 42 ancestral groups allows exploration of the degree to which groups of varying cultural differentiation from Australian society cluster in different parts of the city.

Multi-scale patterns: a cartographic exploration

To provide an introductory appreciation of the geographies of ancestry groups within Sydney, illustrating their multi-scalar character, Figures 1-3 are maps showing the distribution of several of the 42 groups. These are constructed at the micro-scale (SA1s), and are split into five unequal categories. The first comprises those which have no representatives from the selected ancestry group. The other four comprise the quartiles of the distribution for the absolute number of group's members. Thus for Figure 1, showing the distribution of those classified as having Australian ancestry (i.e. who regard themselves as Australians with no other ancestral attachments), the SA1s were ordered according to the absolute number of Australians there [for which the total was 919,292 responses]. The SA1s included in Q1 on the map are the smallest number of such areas that contain one-quarter of all Australians in Sydney. The fewer the SA1s in Q1, the greater the group's concentration within particular parts of Sydney. Q2 comprises SA1s with the next one-quarter of all Australians; Q3 contains the next quarter and Q4 the remaining SA1s (i.e. the areas where Australians are least concentrated). The map thus gives a general view of both how widely distributed Australians are within the metropolitan area and the degree to which they are concentrated in specific parts. Regarding their distribution, there is a clear suburban/city split:

'Australians' are relatively few in number in much of central Sydney, especially the areas to the west of the CBD (i.e. the SA1s in Q4), but are widely distributed through the suburbs (Poulsen et al., 2004). Regarding the second element, their concentration, a large number of SA1s are in Q1, suggesting relatively little segregration at the micro-scale.

The data in the first row of Table 1 summarise that distribution, showing the number of SA1 areas (neighbourhoods) in each quartile, plus the number of areas – just two – with no residents claiming Australian ancestry. If Australians were evenly distributed across Sydney, 2,236 SA1 areas would appear in each quartile, and there would be none in the final column. The degree of deviation from such a distribution is indicative of the degree of segregation: one-quarter of all 'Australians' in Sydney live in just five per cent of its neighbourhoods.

The four maps in Figure 2 show the geographies of some of Sydney's longest-established groups. That for the UK British (Figure 2a) has much in common with Figure 1: clear concentration in many of the outer suburbs but little micro-scale congregation. Greeks, on the other hand (Figure 2b), most of whom (or their parents or grand-parents) arrived in the 1950s and 1960s, are heavily concentrated to the south of the city centre (see Burnley, 2005), in parts of which the clustering of Q1 SA1s suggests neighbourhood micro-scale segregation alongside macro-scale segregation in that part of the city: one-quarter of them, as shown in Table 1, are concentrated in just 3.6 per cent of the city's neighbourhoods. A similar bipolar pattern is also clearly indicated for the Maltese (Figure 2c), most of whom arrived contemporaneously with the Greeks – but at the macro-scale they are concentrated in the northwest (see Waitt et al. 2001). Finally, those with Polish ancestry (the majority of whom arrived from the 1980s on) are more widely scattered throughout Sydney (Figure 2d), with some micro-scale concentrations (such as in the eastern suburbs where most Polish Jews settled after World War 2 (cf. Fig. 4).

Figure 3 portrays the geographies for four Asian groups, all relatively recent arrivals (i.e. mostly post-1980). Those of Chinese ancestry are heavily concentrated in a number of locations (Figure 3a), both in lower to lower-middle socio-economic status (SES) areas south of and higher SES areas north of the city centre (see Burnley, 2002); they are absent (either totally – areas where there are no Chinese – or relatively – the SA2s in the Q4 grouping) from much of outer suburban Sydney. Few Koreans are to be found throughout much of Sydney, however (Figure 3b), and their main concentrations coincide with some of those areas where Chinese are also clustered in northern and inner parts of the city (see Han and Han, 2010). Many of the city's Vietnamese either migrated to Australia as refugees in the 1970s and after, or are the descendants of that group: they are very heavily concentrated in one segment of the lower SES southwestern suburbs only (Figure 3c), where the small number of Q1 SA1s suggests strong segregation at the micro- as well as the macro-scale (see Dunn, 1993). Finally Filipinos (Figure 3d) are both concentrated in some western and southwestern suburbs but are also widely distributed through much of the rest of Sydney, the latter aspect reflecting that many work in lower status, especially domestic, service industries (see Jackson, 1989). All four groups are heavily concentrated into relatively few neighbourhoods (Table 1), and are entirely absent from many parts of the city.

Modelling segregation

These maps provide an initial overview of elements of Sydney's ancestry geographies, offering clear circumstantial support to arguments that those patterns are multi-scalar in their composition: each group is, to a greater or lesser extent, both concentrated in some parts of the metropolitan area but absent from others and also clustered in particular suburbs and neighbourhoods within those favoured larger districts. To evaluate the extent of this segregation we use a recently-developed multi-level modelling procedure based on Bayesian statistical principles (Jones et al., 2015; Manley

et al., 2015) which is a major advance on most other segregation measures that look at the situation of each scale independently.[2] Its measure of segregation – the Median Rate Ratio (MRR) – has associated Credible Intervals (CIs: interpreted in the same way as confidence intervals; because they are Bayesian they are not necessarily symmetric around the estimated MRR value), which allows rigorous comparisons (i.e. the equivalent of statistical significance tests without making asymptotic normality assumptions) between, for example, the level of segregation for any one group at two separate scales or the level of segregation for two different groups at the same scale. (Full details of the modelling procedure are given in Jones et al., 2015.)

Importantly, the MRR values for each scale are net of any segregation at a larger scale, thereby addressing the important issue regarding missing scales raised by Tranmer and Steel (2001). For example, the MRR for Chinese at the SA1 scale indicates how segregated they are at the neighbourhood level, when segregation at each of the three larger scales is held constant: it is thus a 'true' measure of segregation at the micro-scale without any contamination by incorporating an unknown amount of segregation at the larger three scales. (If, for example members of a group were all concentrated in a single macro-scale area but evenly distributed across the SA1s within that area, the MRR for the former scale would be large but that for the latter would be zero.)

MRRs are absolute measures of segregation, which can be interpreted using the Cohen's (1988) – albeit arbitrary – categorisation for the effect sizes of odds ratios. Values greater than 4.3 indicate very large ratios, and hence high degrees of segregation (at that scale); MRRs between 2.5 and 4.3 and between 1.5 and 2.5 indicate medium and small levels of segregation respectively; and MRRs less than 1.5 are considered low. An MMR of exactly 1.0 would represent an even distribution across the areal units and so indicate no segregation for the ancestry group concerned at the relevant scale.

Segregation in Sydney, 2011

The MRR values for the 42 ancestry groups at each scale are in Table 2: the first set of six ancestries comprises those culturally most similar to 'Australians'; the others are arranged in groups by geographical area of origin, with the Jewish ancestry group separated out as its members have a variety of geographical origins. Using the Lower and Higher CI values (i.e. those encompassing 95 per cent of all the likely estimated MRR values) allows an evaluation of whether two MMR values are significantly different from each other. For example, MRRs for the Jewish group indicate that it was highly segregated at both the macro-scale [MRR 20.78; CIs 10.48-48.06] and, to a lesser extent, at the micro-scale [MRR 8.52; CIs (7.47-9.83)] with the former being significantly greater than the latter because the two CI distributions do not overlap. Segregation is much lower at the two meso-scales; those MRR values (3.54 and 4.66) are substantial but are not significantly different from each other; both, however, are significantly smaller than those for the micro- and macro-scales. People with Jewish ancestry in Sydney are significantly concentrated in particular macro segments of the city, therefore (mainly in the eastern suburbs: Figure 4 and Table 1), and within those macro-segments are strongly clustered in particular neighbourhoods at the SA1 scale.

[2] Fowler (2015, p. 3) criticises multi-level modelling approaches because, although they 'acknowledge the importance of multiple scales in shaping outcomes, they tend to conceptualize scale as hierarchical and clearly bounded in ways that many geographers find problematic'. The multi-level approach adopted here indeed uses a nested hierarchy of areas. This may not necessarily be the case; the boundaries of 'real' neighbourhoods into which groups are clustered at one scale (and in which the neighbourhood effects about which Foster writes operate) may not coincide with those at other scales – posing a further challenge for work adopting the present approach, perhaps to incorporate the more flexible method adopted by Östh et al. (2014; Clark et al., 2015). The nested hierarchy structure deployed here in a strict modelling framework nonetheless provides robust estimates of multi-scalar segregation intensity, and could be adapted accordingly.

Brief inspection of Table 2 indicates that in many of the 42 cases segregation is higher at the macro- and micro-scales than the two meso-scales. Most groups are concentrated into particular macro-scale (regional) segments of Sydney, but within them there is little clustering at the meso-scales; net of those macro- and meso-scale patterns, however, there is then considerable concentration at the neighbourhood or micro-scale, suggesting a two-scale process of residential decision-making to which we return below. There are substantial variations around that general pattern, however, notably in the levels of segregation rather than in the differences across the four scales. Thus for the dominantly English-speaking cultural groups in the second set of six ancestries and the five northern and eastern European groups in the next set very few MRRs fall outwith the two lowest categories in Cohen's (1988) scheme – they are less than 2.5; the main exception is the New Zealand Maori population (on which see Forrest et al., 2009). A similar situation applies to the Greeks, Italians and Maltese who migrated to Australia in substantial numbers in the early post-Second World War decades; they too are relatively weakly segregated at all scales – with the partial exception of the Maltese. They are significantly more segregated than the Australians at the micro- and macro-scales, however, with higher MRR values and CI spans that do not overlap with those of their 'host society'; the highest MRR value for Greeks is at the macro-scale, a result consistent with the mapped pattern in Figure 2b. Most of the other European groups are also significantly more segregated than the Australians.

Much higher MRR values are the norm further down the table – some are substantially larger than 4.3, indicative of very substantial segregation, nearly always at either or both of the micro- and macro- scales, with virtually none at either of the meso-scales. The highest levels of segregation for these groups are generally at the micro- rather than the macro-scale, although almost all have macro-scale MRR values exceeding 2.5, indicating clustering in particular segments of Sydney only. For nearly all of them the higher micro-scale MRRs indicate substantial congregation into particular small neighbourhoods within their favoured parts of the metropolitan area.

To establish which groups were most and which least segregated, the information in Table 2 has been reorganised in Table 3, for the macro- and micro-scales only and without the CI values, with the ancestry groups ordered according to their MMR values. Most MRRs were not significantly different from that immediately above them in the rank ordering, however, especially at the macro-scale, reflecting the wide span of the CIs at this scale for which there is a relatively small number of observations (45). At the macro-scale, therefore, although there are substantial differences between the groups' MRRs – that for the Jewish group is three times as large as that for those from the Former Yugoslav Republic of Macedonia – many are not significantly different from each other. The first MRR significantly smaller than that for the Jewish population is for Pakistanis, and this difference is indicated by a line separating them from the Macedonians immediately above them. There is then no significant difference between the MRR for the Pakistanis and the next 10 ancestry groups, but there is between the Pakistanis and the Serbians – hence a further dividing line in the table. Overall, there are only five blocks of ancestry groups whose MRRs are significantly different from those above them in that section of the table.

A clear general pattern emerges in the upper block of Table 3, therefore; at the macro-scale the Jewish were the most segregated and the Australians the least. Apart from the Jewish and FYRoMacedonians, all of the most segregated – those in the 'top 14' (i.e. the left-hand column) – have Asian origins. This contrasts with the lowest values (i.e. the right-hand column) which, with the exception of the Malay and New Zealanders, are European. These differences are largely commensurate with the inter-group differences in the decade in which those associated with the various ancestries mostly first entered Australia, shown by the data in Table 4. In this, the groups are ordered according to their percentage entering Australia in the 1940s-1950s: where the percentage arriving in this period is the same, the column is organised by their percentage arriving in the 1960s-

1970s. Among those least segregated at that scale, shown in the right-hand column, only three groups (Malay, Thai and New Zealanders) were not among those with the highest percentages who had come to Australia in those early post-war decades.[3] The longer an ancestry group had been established in Sydney, the more widely its members were distributed across the city's macro-scale areas, which probably reflects second and third-plus generation spatial assimilation among those in Australia the longest.

At the micro-scale, Table 3's lower block has substantial differences in its ordering of the 42 groups from the macro-scale, as well as many more very large MRR values indicating substantial segregation at the neighbourhood scale. There are also many more significant differences, especially at the lower levels of segregation: each of the nine least-segregated groups is significantly less segregated than that immediately above it in the rank ordering. In general, the most segregated groups at this scale were not only culturally distinct from those with an English-speaking heritage but also small: the first four in the rank ordering, for example, were the smallest of the 42 groups analysed – with populations of 2,320, 4,064, 4,034 and 4,772 respectively; only the Serbians had more than 20,000. Of the least segregated, on the other hand, only those who gave their ancestry as New Zealanders of the 14 groups in the right-hand column had a Sydney population of less than 30,000, and of the groups with more than 25,000 members, only the Southern Africans, Russians, Iraqis and Koreans were not among the 14 least segregated.

Segregation profiles

Tables 1-3 provide a valuable overview which groups are more segregated than others in Sydney, and at what scales. Greater clarification is provided by compressing that mass of information into more general patterns. The 42 ancestry groups' profiles of MRR values across the four scales were classified using Ward's k-cluster method. Six clusters were extracted; their mean MRR values at each scale are in Table 5 and Figure 5.

As the data in Table 4 show, and Figure 5 confirms, all six profiles are U-shaped, with relatively high levels of segregation at the macro- and micro-scales and low at the two meso-scales. The differences among the six categories lie in the size of the average MRR values at the former two scales. For the biggest two categories (5 and 6) the average MRR value is larger at the micro- than at the macro-scale, though only slightly so in the case of category 5. The latter comprises all of the European (including British) ancestry groups and a small number of others, most of which are long-established in Australia. They are the least segregated overall, being fairly widely distributed through the entire metropolitan area and only slightly more clustered at the neighbourhood scale. The category 6 ancestry groups – mainly of Asian provenance, who arrived from the later 1970s – have the same overall profile but are substantially more segregated at both macro- and, especially, micro-scale; more than any other groups they are concentrated into particular parts of metropolitan Sydney and, within them, certain neighbourhoods only.

Each of the four smaller categories (1-4) – with two exceptions (Bosnian and Jewish) all of the constituent groups are again of Asian provenance – are much more segregated at one or both of the macro- and micro-scales, with three (1, 2 and 4) having higher average MRR values at the micro- than the macro-scale. All are very highly segregated at the micro-scale, but two – 1 and 4 – much less so at the macro-, although even at the latter all but the first category have relatively high values on the macro-scale as well. These groups are both concentrated in particular parts of city and, within those parts, heavily congregated into particular neighbourhoods. Most, though not all, originated in refugee streams.

[3] There are no data, of course, for those with Australian ancestry.

Together or apart

The discussion so far has highlighted the multi-scalar pattern of segregation for each of the ancestry groups and shown that most have the same general profile – segregation is highest at the macro- and micro-scales. What has not been demonstrated is the extent to which each ancestry group shares space with or is segregated from the others. This can be assessed from the MRR calculations, which are based on the ratio of the number of individuals in an ancestry group observed in each area, at the relevant scale, to the number that would be there if that group was distributed across the areas in line with the distribution of the total population. Those ratios are used to calculate the variance in each distribution, from which the covariance and hence the correlation between any two distributions at each specific scale are calculated. Those correlations range from -1.0 to +1.0, and are interpreted in the same way as standard product-moment correlations. (Full details are provided in Jones et al., 2015.)

The full 42x42 correlation matrix at each scale is not reproduced here; rather, as the previous analyses have shown that segregation is greatest at the macro- and micro-scales, only those are presented. Table 6 shows the inter-correlations within each of a number of ancestry groups according to geographical and/or cultural origins; Table 7 gives the correlations for each of the 41 other groups with the Australians to explore their degree of separation from the 'host society'.

With few exceptions, one very clear pattern emerges from Table 6. Within each of the selected sets there are relatively high positive correlations at the macro-scale, but much smaller ones – some of them negative – at the micro-scale. Thus ancestry groups from the same geographical parts of the world tend to be concentrated in the same parts of Sydney at the macro-scale: different groups have gravitated to the same parts of the metropolitan area. But holding that pattern constant (recalling that the segregation measures at the micro-scale are net of those at the macro-scale) they are not also clustered into the same neighbourhoods within respective macro-scale areas. For example, the five ancestry groups from South Asia (Bangladeshi, Indian, Pakistani, Sri Lankan and Sri Lankan Tamil) are concentrated in the same macro-scale parts of Sydney (the smallest of the correlations at that scale is +0.429), but within those regions they are congregated in different micro-scale neighbourhoods (no correlations at that scale area as high as +0.400 and most are below +0.200).

Across the different groupings used in Table 6, by far the strongest macro-scale correlations are for the last, which comprises those of Australian ancestry plus others with a common cultural and linguistic background, most of which are long-established in the country. They are all – with the partial exception of Southern Africans, most of whom are relatively recent arrivals – concentrated in the same parts of Sydney (the suburbs, as indicated in Figures 1-3). But there is greater separation at the micro-scale in most cases. Only the Australians, the UK British and the Irish tend to share space at the neighbourhood scale; the New Zealanders and Southern Africans tend to cluster in separate neighbourhoods, not only from each other but also from the British, Irish and Australians.

The small number of exceptions from the general trend – of groups from similar geographical origins being located in the same general parts of Sydney but not the same neighbourhoods therein – suggest particular features of immigrant settlement in Australia; the Italians and Maltese congregate in different macro-scale segments from the Greeks, for example. Similarly, among the Southeast Asian groups there is macro- as well as micro-scale separation of Burmese and Thai. Among the Indochinese and East Asian groups, whereas the Vietnamese and Chinese tend to cluster in the same macro-scale districts this is not also the case with the Vietnamese, Japanese and Koreans; those from Cambodia (Khmer) and Laos are almost totally separated from all three East Asian groups.

Finally, the correlations for each of the 41 other ancestry groups and the Australians indicate some relatively stark differences at the macro-scale (Table 7): positive correlations show that some groups tend to congregate in the same parts of Sydney as their 'hosts' (notably the Dutch, French and German plus, as already noted, the Irish, UK British and New Zealanders), whereas substantial negative correlations indicate that other groups are to be found where the Australians are relatively absent – including most of the ancestry groups with Asian roots (though excepting both groups from Sri Lanka, plus Afghans, Iranians and the Japanese). At the micro-scale, however, most of the correlations are small and many of them negative. Across Sydney's local neighbourhoods, Australians (and also, by implication from their correlations, the Irish and UK/British) tend to be absent from such micro-scale elements of the urban residential fabric where there are substantial numbers from most other ancestry groups.

Discussion: residential location decision-making at two scales?

Several main conclusions emerge from this first evaluation of the multi-scale segregation of Sydney's ancestry groups. The first relates to that multi-scale feature of the phenomenon. For virtually all 42 separate groups analysed segregation is greater at the macro- and micro-scales than at the intermediate meso-scales. Each group is concentrated, to a greater or lesser extent, in certain macro-scale segments of the urban residential fabric, within which they are relatively evenly distributed across the meso-scale districts and suburbs But within the meso-scale areas – again, to a greater or lesser extent – they are concentrated in certain micro-scale neighbourhoods and relatively absent from others.

Although this general pattern applies across almost all 42 groups, the detailed data in Table 1 summarised in Figure 5 show that it varies in its intensity: some groups are much more segregated at both macro- and micro-scale than others. In general, the larger groups, those longer-established in Australia, and those culturally most similar to those of the majority English-speaking background population, are the least segregated – hence the major difference shown in Table 4 between those from Asian backgrounds on the one hand and from European and English-speaking backgrounds on the other.

The macro- and micro-segregation patterns differ in their detail, however. At the former scale, relatively high positive correlations (Table 6) within particular subsets of the 41 non-Australian ancestral groups – defined mostly by their geographical origins – show that members of those subsets tend to be clustered in the same macro-scale regions of Sydney: members of all five South Asian ancestry groups are relatively numerous in the same regions and relatively absent from the others, for example. But relatively small correlations at the micro-scale show that they are not concentrated in the same neighbourhoods within those regions. There is a fine-grained geography of residential differentiation within the coarse-grained pattern. At the macro-scale, Sydney is a divided city as between those of English speaking and non-English speak backgrounds; at the micro scale it displays a much more of complex residential mosaic (cf. Poulsen et al., 2004).

These general findings provide the empirical foundations for the development of a multi-scale explanation. Each group, it seems, favours some regions within the metropolitan space over others and, within them, favours some neighbourhoods over others. Use of the term 'favours' suggests that these geographies are the result of the exercise of choice, but for many that choice may have been considerably constrained. Most of the original settlers in each of the ancestry groups – notably those from continental Europe and from many parts of Asia – arrived with few resources and little ability to compete within the major segments of the metropolitan housing market as determined by property values and rent levels, reflecting their labour market situations (Forrest et al., 2013, 2014). Only certain areas – almost invariably those with low cost, relatively low quality housing – will have

been available to them. There was probably more than one region of Sydney with such characteristics, given its size, and it may have been no more than serendipitous which of those regions the original settlers chose. Having selected that region, however, others from their country of origin who joined them – many through the well-established mechanism of chain migration – will have 'chosen' the same region and neighbourhoods, so that the bi-scalar clustering is accentuated, even into the second generation (Burnley, 1996, 2005).

The nature of their 'selection' will obviously reflect the structure and operation of the housing market at the time of arrival. Some, especially refugee groups, for example, may have qualified for public sector housing, which was allocated according to household size and relative poverty with no preference given to particular ancestry groups; the availability of such housing will have determined in which macro-region particular groups were concentrated. As any group expands, through a combination of natural increase and in-migration, so its cluster is likely to expand too, again increasing the degree of both macro- and micro-scale segregation. Expanding groups compete for space within the housing market and, as far as is possible, move into neighbourhoods adjacent to those where they initially settled, so that different groups although concentrated within the same urban region tend to live apart from each other in different neighbourhoods.

While this well-established 'theory' linking labour and housing markets to residential segregation has general application across an urban population, it applies more to some ancestry groups than others. Those groups whose members are less disadvantaged in the labour and hence housing markets are less constrained in their choices of where to live and less likely to congregate strongly in particular parts of the city – a situation most likely to apply to those groups who are culturally similar to the 'host society' (particularly those from the UK, Ireland and New Zealand and, to a lesser extent, parts of Europe: see Markus et al., 2009). They have a wider choice and are unlikely, for cultural or other reasons, to want to congregate with those from the same background as themselves to the same extent. Nevertheless, they are likely to avoid many of the regions let alone neighbourhoods where other groups are concentrated – at least because they can afford higher quality housing than can be found there and, in some cases at least, because of the negative stigma associated with such areas and their residents (Merry, 2015).

The geography of which ancestry groups are to be found where within a city is constantly changing, in part as a consequence of relative shifts in group size, in part because of changes in people's residential aspirations and choices, and in part because of the degree to which they integrate into the host society and economy. In some situations the substantial expansion of one group around its core neighbourhoods can impel other groups to leave them – producing the classic 'invasion and succession' sequence identified in many cities over the last two centuries. This will change the 'where' of a segregation pattern but not necessarily its intensity. The latter will almost certainly change, however, as the factors encouraging segregation themselves become less intense: economic integration, for example, may give many group members a wider choice set of areas in which they can afford to live, while cultural assimilation may mean they are less tied to living in close proximity to their co-ethnics. As this occurs, so micro-scale segregation may decline, as neighbourhoods become more mixed in their population characteristics – especially those into which the upwardly mobile move. But the macro-scale segregation may not be reduced to the same extent.

In a large metropolitan area such as Sydney most people move only relatively short distances, preferring to remain within the same region – or to move to one nearby – rather than make a long-distance move to an entirely different region. This will partly reflect their action and associated search spaces – unless they have pressing reasons to move well away from their current home most search for another relatively close to it, probably also reflecting the desire to retain access to certain facilities – places of work, worship and schooling, for example – and/or to people and cultural

institutions and with whom they wish to maintain ties. Distance is not necessary to such strategies, but can be a strong influence. For such groups, macro-scale segregation is likely to be as high, if not higher, than micro-scale segregation; they remain concentrated in particular regions within the city but are not as concentrated in certain neighbourhoods within those regions; such micro-scale concentration is more likely to be a characteristic of the smaller, more recent arrival groups who are less economically integrated and culturally assimilated.

These elements of a bi-scalar 'theory' of residential segregation patterns are not, of themselves, new, but many studies do not bring them together. In large part this is because empirical studies of segregation are predominantly single-scale and that scale is almost invariably micro-; having described a pattern of neighbourhood segregation the emphasis on accounting for it is at that scale too. The empirical results of a multi-scale analysis undertaken here indicate that is insufficient. Not only are most groups segregated at the macro- as well as the micro-scale, this is almost certain to be the case given the decision-making processes underpinning housing and area choice. Unless a group is concentrated in a number of neighbourhoods only, and those neighbourhoods are either uniformly or randomly distributed across the urban mosaic, then any distribution will have segregation components at the macro- (and perhaps also the meso-) as well as the micro-scale. To appreciate such spatial structuring we need a theoretical framework within which accounts of why groups are found where they are – why, for example, Sydney's Jewish population is concentrated in just two particular regions of the city as well as within certain neighbourhoods there (presumably for access to synagogues, schools and other cultural facilities) – can be set.

Conclusions

This paper has made several innovative contributions to the study of urban residential segregation, reinforcing and developing other recent studies that have taken different approaches to recognition that segregation is multi-scalar in nature. Some of these innovative contributions are methodological. Here, a recently developed alternative measure to those usually deployed to identify the intensity of segregation has been applied. Like others, it decomposes the level of observed segregation at a number of hierarchically-nested spatial scales – accepting that those scales (their number and delimitation) are to a greater or lesser extent arbitrary and recognising the need for further research into those issues.[4] That measure differs from others proposed recently for this task in that it is based on a formal modelling procedure within a very well-developed framework (multi-level modelling), which allows statistical significance testing of differences in, for example, the level of segregation for the same group at different scales and for different groups at the same scale. Like so many other measures it represents segregation by a single number, but one whose value can be evaluated within the language of inferential rather than descriptive statistics. It also produces a separate segregation measure for each group at each scale, rather than the composite measure of diversity used in other studies.[5]

Alongside methodological innovation the paper has advanced empirical studies in a number of novel ways. The rich data available from the Australian census – not only in the range and nature of the data collected but also in the facility allowing the individual returns to be manipulated to meet the requirements of particular studies without breaching confidentiality constraints – allowed exploration of the residential patterns of a multi-cultural, multi-ethnic metropolis in much greater detail than is the norm in studies elsewhere. Not only has this allowed a much finer-grained investigation but it has also facilitated a much more nuanced appreciation of variations in

[4] These should include, for example, testing the robustness of the findings by undertaking simulation studies using a range of aggregations of the lowest level units into larger areas.

[5] The entropy measure can be decomposed – as Reardon et al. (2000) show – but interpretation is not always straightforward and there is no statistical framework for evaluating a purely descriptive statistic.

segregation levels. It is widely assumed, as Logan et al. (2015a, 1077) put it, 'that segregation is higher at a finer spatial scale, which is already known' (see also Logan et al., 2015b); the results presented here suggest that this is not always the case – in part, undoubtedly, because (as Tranmer and Steel, 2001, and Duncan et al. 1961 brought to our attention some years ago) segregation measures at fine spatial scales necessarily incorporate those at (unobserved) coarser scales.

These empirical results show that segregation is greater in Sydney among the smaller ancestral groups, those that have most recently arrived in the city, and those who are culturally most distinct from their host society. Furthermore, although groups from similar spatio-cultural backgrounds tend to concentrate in the same parts of Sydney at the macro-scale, they have congregated into separate neighbourhoods within those areas at the micro-scale. These findings may not apply in other places, and/or at other times, but provide a clear stylised fact as far as contemporary Sydney is concerned. But it may have wider application. One criticism of some segregation studies is that their descriptive value is not backed up by a comparable (theoretical) appreciation of processes – a challenge that applies in particular, as Fowler (2015) has stressed, to studies of segregation as a multi-scalar phenomenon. This study of Sydney has addressed that challenge by outlining an explanatory framework that explicitly addresses the multi-scalar processes leading to the observed patterns. That framework is but an initial essay, but as work on the multi-scalar characteristics of segregation is extended it will be accompanied by further essays into their explanation.

Segregation itself is a multi-faceted concept, and its measurement by single numbers – whether the indices classified by Denton and Massey (1988) in their classic study, or the alternative (MRR) proposed here – is far from a complete treatment of that complexity. As argued elsewhere (Johnston et al., 2009, 2010), for example, such indices tell us nothing of the ethnic composition of individual neighbourhoods. Nevertheless, such indices make valuable contributions to describing segregation levels, especially when, as in this study, they have a statistical base that allows comparisons set within an inferential framework.

This application of the modelling procedure deployed here has explored only one element of Sydney's residential structure. By looking only at ancestral groups it has not considered many other dimensions of that structure – related to occupational class and income, for example, as well as to household structure and lifestyle. Further explorations are also possible using the ancestry variable – looking at inter-generational differences in segregation, for example. The potential for the procedure, as illustrated here, is both substantial and significant and represents a substantial forward movement in segregation studies.

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Table 1. The distribution of the number of SA1 areas housing each quartile of an ancestry group's members (for those groups shown in Figures 1-4), plus those SA1 areas from which the group is totally absent.

	Q1	Q2	Q3	Q4	None
Australian	286	1,044	1,107	6,305	2
UK British	1,088	1,520	2,063	4,271	2
Greek	321	750	1,579	4,428	1,866
Maltese	320	715	1,251	2,748	3,910
Polish	551	918	1,451	2,368	3,656
Chinese	393	853	1,655	5,506	537
Korean	130	367	813	2.426	5,208
Vietnamese	137	269	659	3,088	4,791
Filipino	229	682	1,414	3,744	2,875
Jewish	47	97	220	569	8,051

Table 2. The segregation measures (MRR) with their associated Credible Intervals (CIs) for each of the 42 ancestry groups at each of the four scales.

Scale	Micro			Meso1			Meso2			Macro		
	LCI	MRR	HCI	LCI	MRR	HCI	LCI	MRR	HCI	LCI	MRR	HCI
Australian	1.20	1.21	1.22	1.17	1.18	1.20	1.17	1.20	1.24	1.26	1.34	1.46
UK British	1.18	1.18	1.19	1.15	1.16	1.18	1.18	1.22	1.25	1.32	1.43	1.57
Irish	1.27	1.28	1.29	1.18	1.20	1.23	1.24	1.28	1.33	1.40	1.54	1.72
New Zealand	2.52	2.59	2.67	1.20	1.25	1.30	1.24	1.31	1.38	1.55	1.75	2.03
NZ Maori	5.34	5.67	6.02	1.53	1.68	1.84	1.20	1.33	1.49	2.18	2.70	3.52
North American	3.70	3.88	4.07	1.20	1.28	1.37	1.35	1.46	1.58	2.40	3.01	3.98
South African	3.97	4.17	4.38	1.37	1.48	1.60	1.64	1.78	1.95	2.28	2.86	3.76
German	1.45	1.47	1.49	1.14	1.16	1.19	1.18	1.22	1.26	1.35	1.46	1.62
Polish	2.62	2.69	2.78	1.18	1.23	1.29	1.21	1.28	1.34	1.41	1.55	1.74
Russian	3.42	3.56	3.71	1.31	1.38	1.46	1.31	.139	1.48	1.64	1.88	2.22
French	3.23	3.36	3.50	1.22	1.29	1.36	1.27	1.35	1.44	1.82	2.12	2.58
Dutch	2.08	2.13	2.18	1.19	1.24	1.28	1.28	1.35	1.42	1.75	2.03	2.43
Jewish	7.47	8.52	9.83	2.77	3.54	4.45	3.51	4.66	6.49	10.48	20.78	48.06
Greek	2.00	2.03	2.07	1.37	1.43	1.49	1.39	1.48	1.58	2.00	2.40	3.00
Italian	1.57	1.59	1.61	1.28	1.31	1.35	1.32	1.39	1.46	1.37	1.45	1.65
Maltese	2.54	2.62	2.70	1.39	1.46	1.53	1.53	1.65	1.78	2.07	2.54	3.26
Bosnian	21.26	25.95	31.96	2.20	2.84	3.66	2.04	2.61	3.39	3.27	4.87	7.80
Croat	3.42	3.55	3.69	1.40	1.50	1.60	1.52	1.64	1.79	1.52	1.73	2.04
FYRoMacedonian	5.56	5.97	6.41	1.67	1.88	2.11	1.84	2.09	2.39	4.50	6.73	10.99
Serbian	6.38	6.85	7.35	1.51	1.69	1.89	1.76	1.97	2.20	2.40	3.10	4.24
Egyptian	5.67	6.03	6.44	1.40	1.54	1.70	1.81	2.03	2.28	2.68	3.54	4.98
Lebanese	2.52	2.58	2.65	1.46	1.54	1.63	1.64	1.76	1.92	3.01	4.02	5.71
Turkish	6.28	6.74	7.25	1.71	1.91	2.15	1.82	2.05	2.38	3.53	4.99	7.58
Afghan	12.45	14.45	16.73	2.37	2.98	3.79	2.44	3.18	4.21	8.48	16.44	36.61
Iranian	7.72	8.38	9.12	1.37	1.58	1.82	1.98	2.29	2.67	2.69	3.63	5.17
Iraqi	5.80	6.30	6.78	1.98	2.34	3.37	2.91	3.55	5.15	5.81	9.62	17.72
Bangladeshi	10.50	1.202	13.40	3.38	4.24	5.25	3.26	4.36	5.66	4.14	6.86	12.43
Burmese	22.84	28.08	34.81	2.16	2.70	3.45	2.25	2.90	3.80	3.47	5.28	8.68
Indian	2.23	2.27	2.31	1.56	1.64	1.73	1.60	1.74	1.90	2.03	2.49	3.19
Pakistani	10.39	11.52	12.81	2.05	2.40	2.82	2.34	2.82	3.44	3.86	5.85	9.62
Sri Lankan	6.28	6.74	7.25	1.51	1.67	1.87	1.89	2.13	2.43	2.60	3.44	4.84
Sri Lankan Tamil	23.23	32.01	41.24	2.24	3.38	5.25	5.87	9.32	15.11	6.69	14.82	37.35
Indonesian	7.50	8.09	8.75	1.75	1.97	2.22	1.86	2.14	2.46	2.11	2.70	3.60
Malay	18.96	22.38	26.56	1.42	1.71	2.05	2.00	2.43	2.96	1.83	2.39	3.23
Thai	8.13	8.83	9.62	1.81	2.01	2.25	1.75	1.98	2.27	1.97	2.45	3.19
Khmer	11.09	12.88	14.92	2.03	2.45	2.94	2.22	2.80	3.51	5.76	9.46	17.62
Laotian	9.91	11.85	13.73	2.99	3.91	5.26	2.70	3.70	6.78	7.31	13.23	26.70
Vietnamese	3.53	3.69	3.86	1.63	1.77	1.95	1.99	2.26	2.84	3.88	5.60	8.80
Chinese	1.62	1.65	1.66	1.41	1.46	1.51	1.50	1.61	1.73	2.05	2.49	3.16
Filipino	2.61	2.67	2.74	1.54	1.61	1.71	1.53	1.65	1.80	2.13	2.63	3.40
Japanese	5.96	6.42	6.93	1.54	1.71	1.91	1.55	1.73	1.95	3.50	4.90	7.40
Korean	3.70	3.86	4.04	1.66	1.80	1.97	1.98	2.23	2.53	3.70	5.29	8.17

Table 3. The ancestry groups rank-ordered according to their MRR values at the macro- and micro-scales

	MRR		MRR		MRR
Macro-scale					
Jewish	20.78	Bosnian	4.87	Thai	2.46
Afghan	16.44	Lebanese	4.02	Greek	2.40
Sri Lankan Tamil	14.82	Iranian	3.62	Malay	2.39
Laotian	13.23	Egyptian	3.54	French	2.13
Iraqi	9.62	Sri Lankan	3.44	Dutch	2.03
Khmer	9.45	Serbian	3.10	Russian	1.88
Bangladeshi	6.86	North American	3.01	New Zealand	1.75
FYRoMacedonian	6.73	South African	2.86	Croatian	1.74
Pakistani	5.85	NZ Maori	2.70	Polish	1.55
Vietnamese	5.60	Indonesian	2.70	Irish	1.54
Korean	5.29	Filipino	2.63	Italian	1.48
Burmese	5.28	Maltese	2.54	German	1.46
Turkish	4.99	Chinese	2.49	UKBritish	1.43
Japanese	4.91	Indian	2.49	Australian	1.34
Micro-scale					
Sri Lankan Tamil	32.01	Turkish	6.74	Polish	2.69
Burmese	28.08	Sri Lankan	6.74	Filipino	2.67
Bosnian	25.95	Japanese	6.42	Maltese	2.62
Malay	22.37	Iraqi	6.30	New Zealand	2.59
Afghan	14.46	Egyptian	6.03	Lebanese	2.58
Khmer	12.88	FYRoMacedonian	5.96	Indian	2.27
Bangladeshi	12.02	NZ Maori	5.67	Dutch	2.13
Laotian	11.86	South African	4.17	Greek	2.03
Pakistani	11.52	North American	3.88	Chinese	1.65
Thai	8.83	Korean	3.86	Italian	1.59
Jewish	8.52	Vietnamese	3.69	German	1.47
Iranian	8.38	Russian	3.56	Irish	1.28
Indonesian	8.09	Croatian	3.55	Australian	1.21
Serbian	6.85	French	3.36	UKBritish	1.18

Table 4. The percentage of the members of each of the first generation of ancestry groups who entered Australia in different decades, rank-ordered according to the percentage of their members who entered in the 1940s-1950s

	1940s-50s	1960s-70s	1980s	1990s	2000s
Bangladeshi	0.0	1.0	4.4	20.8	73.8
Afghan	0.0	1.0	9.7	32.3	57.0
Sri Lankan Tamil	0.0	3.2	22.7	32.7	41.5
Khmer	0.0	5.3	48.7	26.1	19.8
Korean	0.0	6.3	18.5	23.8	52.4
Filipino	0.0	6.8	30.3	29.5	33.3
Vietnamese	0.0	13.1	40.6	28.4	18.0
Laotian	0.0	34.8	48.0	10.6	6.6
Thai	0.1	4.1	17.1	20.2	58.7
Iraqi	0.1	6.2	4.4	33.4	56.0
NZMaori	0.2	8.3	20.3	23.9	47.4
Iranian	0.2	9.1	25.0	23.9	41.8
Sri Lankan	0.2	9.2	20.1	31.2	39.3
Pakistani	0.3	3.4	12.8	24.4	59.1
Turkish	0.4	42.6	19.6	18.7	18.8
Indian	0.6	5.8	6.7	17.9	69.0
Malay	0.9	18.9	32.1	16.7	31.5
Bosnian	1.0	15.5	5.9	62.6	15.1
Burmese	1.1	11.9	13.2	30.6	43.2
Chinese	1.2	5.4	18.1	29.3	46.1
Japanese	1.3	6.1	15.4	26.7	50.5
New Zealand	1.3	16.8	19.8	20.3	41.8
Indonesian	1.4	7.8	16.7	28.3	45.8
North American	1.6	18.1	13.6	18.9	47.9
FYRoMacedonian	1.9	63.4	14.3	11.6	8.8
Irish	3.8	22.0	17.7	14.4	42.0
Serbian	3.1	42.4	12.9	25.8	15.8
Lebanese	3.3	44.4	20.1	16.1	16.1
French	5.1	19.9	10.9	13.2	50.9
Southern African[1]	8.2	33.3	14.2	13.1	31.3
Croatian	8.5	60.5	5.6	16.3	9.0
Russian	9.3	9.5	7.6	38.7	35.0
UKBritish	9.7	36.9	17.7	14.4	42.0
Jewish	11.9	17.2	21.0	31.5	18.5
Egyptian	12.6	35.4	16.5	16.4	19.0
Polish	15.8	12.8	41.8	14.3	15.3
Greek	24.7	69.6	3.7	2.0	2.0
German	32.2	24.2	10.1	9.0	24.4
Italian	37.6	52.1	3.2	2.2	5.0
Dutch	43.4	23.2	8.3	6.8	18.3
Maltese	44.9	46.3	6.0	1.3	1.5

[1] South African, Zimbabwean, Zambian

Table 5. The classification of ancestry groups according to their segregation profiles: the average MRR values for each class and the class memberships

	Scale			
Category	Macro	Meso2	Meso1	Micro
1	4.17	2.65	2.42	25.47
2	14.81	9.32	3.38	32.01
3	14.32	3.98	3.67	11.72
4	8.31	3.06	2.40	10.32
5	2.17	1.45	1.37	2.61
6	4.21	2.08	1.78	6.50
Category members				
1				
Malay	Bosnian	Burmese		
2				
Sri Lankan				
3				
Afghan	Bangladeshi	Jewish	Laotian	
4				
Iraqi	Khmer	Pakistani		
5				
Australian	UKBritish	Chinese	Croatian	Dutch
Filipino	French	German	Greek	Indian
Irish	Italian	Lebanese	Maltese	NZMaori
New Zealand	North American	Polish	Russian	Serbian
6				
FYRoMacedonian	Indonesian	Iranian	Japanese	Korean
Sri Lankan Tamil	Thai	Turkish	Vietnamese	Egyptian
Southern African				

Table 6. Inter-correlations of the segregation patterns at the macro- and micro-scales for different ancestry groups.

Southern Europe					
	Greek:Italian	Greek:Maltese	Italian:Maltese		
Macro-	+0.040	+0.047	+0.651		
Micro-	+0.291	+0.134	+0.206		
Balkans					
	Bosnian:Croatian	Bosnian:FYRoM	Bosnian:Serbian	Croatian:FYRoM	Croatian:Serbian
Macro-	+0.611	+0.676	+0.565	+0.486	+0.618
Micro-	+0.009	+0.012	+0.122	+0.056	+0.082
	FYRoM:Serbian				
Macro-	+0.464				
Micro-	+0.106				
South Asia					
	Bangla:Indian	Bangla:Pakistani	Bangla:SLankan	Banga:SLTamil	Indian:Pakistani
Macro-	+0.616	+0.627	+0.429	+0.500	+0.736
Micro-	+0.375	+0.111	+0.115	+0.124	+0.193
	Indian:SLankan	Indian:SLTamil	Pakistani:SLankan	Pakistani:SLTamil	SLankan:SLTamil
Macro-	+0.731	+0.772	+0.588	+0.644	+0.857
Micro-	+0.166	+0.044	+0.113	+0.037	+0.065
Southeast Asia					
	Burmese:Indonesn	Burmese:Malay	Burmese:Thai	Malay:Indonesn	Malay:Thai
Macro-	+0.413	+0.356	+0.025	+0.647	+0.441
Micro-	+0.079	+0.060	+0.063	+0.100	+0.119
	Indonesn:Thai				
Macro-	+0.521				
Micro-	+0.140				
Indochina and East Asia					
	Khmer:Laotian	Khmer:Vietnamese	Khmer:Chinese	Khmer:Japanese	Khmer:Korean
Macro-	+0.586	+0.491	+0.078	-0.427	-0.294
Micro-	+0.010	+0.059	+0.111	+0.109	+0.020
	Laotian:Chinese	Laotian:Japanese	Laotian:Korean	Vietnam:Chinese	Vietnam:Japan
Macro-	+0.140	-0.388	-0.228	+0.454	-0.162
Micro-	+0.108	+0.035	-0.001	+0.156	-0.022
	Vietnam:Korean	Chinese:Japanese	Chinese:Korean	Japanese:Korean	
Macro-	+0.042	+0.369	+0.655	+0.511	
Micro-	+0.023	+0.137	+0.248	+0.130	
West and North Europe					
	Dutch:French	Dutch:German	Dutch:Polish	Dutch:Russian	French:German
Macro-	+0.584	+0.818	+0.328	+0.167	+0.702
Micro-	+0.055	+0.117	+0.058	+0.028	+0.081
	French:Polish	French:Russian	German:Polish	German:Russian	Polish:Russian
Macro-	+0.371	+0.491	+0.418	+0.279	+0.469
Micro-	+0.018	+0.039	+0.120	+0.070	+0.178
English-Speaking					
	Australian:Irish	Australian:NZ	Australian:SAfrican	Australian:UK	Irish:NZ
Macro-	+0.584	+0.813	+0.324	+0.906	+0.857
Micro-	+0.502	+0.109	-0.054	+0.702	+0.071
	Irish:SAfrican	Irish:UK	NZ:SAfrican	NZ:UK	SAfrican:UK
Macro-	+0.813	+0.806	+0.733	+0.777	+0.691
Micro-	-0.030	+0.758	+0.021	+0.112	-0.034

Table 7. Correlations of the segregation pattern for each of 41 ancestry groups with those for those recording Australian ancestry, at the macro- and micro-scales.

	Greek	Italian	Maltese	Bosnian	Croatian	FYRoM	Serbian
Macro-	-0.423	-0.381	+0.087	-0.430	-0.404	-0.400	-0.424
Micro-	+0.155	+0.200	+0.161	-0.075	+0.021	-0.029	-0.083
	Dutch	French	German	Polish	Russian	Jewish	NAmerican
Macro-	+0.736	+0.312	+0.662	+0.210	-0.112	-0.007	+0.395
Micro-	+0.140	+0.020	+0.194	-0.010	-0.090	+0.006	+0.092
	Irish	NZ	NZMaori	SAfrican	UK	Egyptian	Lebanese
Macro-	+0.873	+0.813	+0.328	+0.324	+0.906	-0.309	-0.263
Micro-	+0.502	+0.109	-0.048	-0.054	+0.702	-0.090	+0.123
	Turkish	Afghan	Iranian	Iraqi	Bangladeshi	Indian	Pakistani
Macro-	-0.532	-0.116	-0.178	-0.470	-0.365	-0.249	-0.224
Micro-	-0.081	-0.170	-0.178	-0.093	-0.263	-0.387	-0.198
	SriLankan	SLTamil	Burmese	Indonesian	Malay	Thai	Khmer
Macro-	-0.042	-0.194	-0.462	-0.457	-0.458	-0.461	-0.303
Micro-	-0.313	-0.211	-0.147	-0.184	-0.167	-0.208	-0.114
	Laotian	Vietnamese	Chinese	Filipino	Japanese	Korean	
Macro-	-0.318	-0.638	-0.679	-0.210	-0.102	-0.322	
Micro-	-0.091	-0.121	-0.471	-0.295	-0.199	-0.263	

Figure Captions

Figure 1. The distribution of those with Australian ancestry in Sydney 2011, at the SA1 level, with the SA3 boundaries also indicated. (Areas shown blank are outwith the Sydney build-up area.)

Figure 2a. The distribution of those with UKBritish ancestry in Sydney 2011, at the SA1 level, with the SA3 boundaries also indicated. (Areas shown blank are outwith the Sydney build-up area.)

Figure 2b. The distribution of those with Greek ancestry in Sydney 2011, at the SA1 level, with the SA3 boundaries also indicated. (Areas shown blank are outwith the Sydney build-up area.)

Figure 2c. The distribution of those with Maltese ancestry in Sydney 2011, at the SA1 level, with the SA3 boundaries also indicated. (Areas shown blank are outwith the Sydney build-up area.)

Figure 2d. The distribution of those with Polish ancestry in Sydney 2011, at the SA1 level, with the SA3 boundaries also indicated. (Areas shown blank are outwith the Sydney build-up area.)

Figure 3a. The distribution of those with Chinese ancestry in Sydney 2011, at the SA1 level, with the SA3 boundaries also indicated. (Areas shown blank are outwith the Sydney build-up area.)

Figure 3b. The distribution of those with Korean ancestry in Sydney 2011, at the SA1 level, with the SA3 boundaries also indicated. (Areas shown blank are outwith the Sydney build-up area.)

Figure 3c. The distribution of those with Vietnamese ancestry in Sydney 2011, at the SA1 level, with the SA3 boundaries also indicated. (Areas shown blank are outwith the Sydney build-up area.)

Figure 3d. The distribution of those with Filipino ancestry in Sydney 2011, at the SA1 level, with the SA3 boundaries also indicated. (Areas shown blank are outwith the Sydney build-up area.)

Figure 4. The distribution of those with Jewish ancestry in Sydney 2011, at the SA1 level, with the SA3 boundaries also indicated. (Areas shown blank are outwith the Sydney build-up area.)